Heat and **temperature** are related and often confused, but they are **not** the **same**.

Heat

Definition: Heat is energy that is transferred from one body to another as a result of a difference in temperature

Symbol: Q

Unit measure: Joules

Particles: Heat is measure of how many atoms there are in a substance multiplied by how much energy each atom possesses.

Ability : Heat has the ability to do work (potential and kinetic energy).

Temperature

Definition: Temperature is a measure of hotness or coldness expressed in terms of any of several arbitrary scales like Celsius and Fahrenheit.

Symbol: T

Unity measure: Kelvin, Celsius, Fahrenheit.

Particles: Temperature is related to how fast the atoms within a substance are moving. The 'temperature' of an object is like the water level - it determines the direction in which 'heat' will flow.

Ability: Temperature can only be used to measure the degree of heat

When you heat a substance, either of two things can happen: the temperature of the substance can **rise** or the state of substance can **change**.

$$Q = m \cdot c_s \cdot \Delta T$$

Q **heat J**

m **mass kg**

c_s **specific heat kJ/(kg °C)**

ΔT **temperature difference**

Thermometer

A thermometer is a device that measures temperature or a temperature variation, Exploiting[1] the principle zero of thermodynamics. The thermometers are based on their physical functioning using :

- The thermal expansion of a liquid, gaseous or solid substance
- The electrical resistance of a material (ex:thermocouple thermometers)
- Other physical quantities

Main types of thermometer

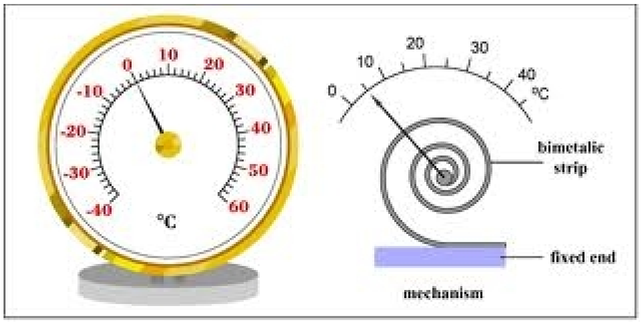
- Mercury thermometer: is composed of a closed glass tube containing mercury. The variation in temperature causes a change in volume of the mercury, which is displayed[2] on a graduated scale near the glass tube.
- Gas thermometer : measure the temperature through the variation of volume or pressure of a gas contained inside a glass tube. The thermometers to gases are very accurate and are used for calibration of other thermometers.
- bimetallic strip thermometer : it is formed by a leaf[3] shaped[4] U or spiral, consisting[5] of two metals with different coefficient of expansion (usually iron and copper[6]) that are welded[7] together, one on the outside, and the other in the inner part of the lamina. One of the border of the lamina is connected to an index[8] that moves along a graduated scale. When the temperature increases, the lamina is curve from part of the metal less expandable and the deformation is transmitted to the index
- Digital Thermometer: uses a sensor consists of a thermistor[9] powered by an electric current. The temperature changes cause in the sensor changes of electrical resistance, that through an electronic circuit is converted into numbers and displayed on a small screen.
- Thermocouple Thermometer: uses a sensor consisting[5] of two metals welded[7]

together which have the property to develop each one a different value voltage as a result of a change in temperature; the measured temperature is therefore proportional to potential difference between the two metals.

Mercury Thermometer

Gas Thermometer

Bimetallic strip thermometer



Digital Thermometer

Thermocouple Thermometer

Infrared Thermometer

[1]Sfruttare [2]visualizzata [3]lamina [4] a forma di [5]costituito da [6]rame [7]saldati

[8]indice [9]termistore

TEMPERATURE SCALES

There are three temperature scales in use today: Fahrenheit, Celsius and Kelvin.

- *Fahrenheit temperature scale* is a scale based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts.

The conversion formula for a temperature that is expressed on the Celsius (C) scale to its Fahrenheit (F) representation is: **F = 9/5C + 32**

Example		
Problem	**The boiling point of water is 100° C. What temperature does water boil at in the Fahrenheit scale?**	
	$F = \frac{9}{5}C + 32$	A Celsius temperature is given. To convert it to the Fahrenheit scale, use the formula at the left.
	$F = \frac{9}{5}(100) + 32$	Substitute 100 for *C* and multiply.
	$F = \frac{900}{5} + 32$	
	$F = \frac{900 \div 5}{5 \div 5} + 32$	Simplify by dividing numerator and denominator by 5.
	$F = \frac{180}{1} + 32$	
		Add 180 + 32.
Answer	The boiling point of water is 212° F	

- *Celsius temperature scale* also called centigrade temperature scale, is the scale based on 0 for the freezing point of water and 100 for the boiling point of water.

Invented by the Swedish astronomer Anders Celsius, it is sometimes called the centigrade scale because of the 100-degree interval between the defined points. The following formula can be used to convert a temperature from its representation on the Fahrenheit (F) scale to the Celsius (C) value:

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Fahrenheit to Celsius:

$$°C = (°F - 32) / 1.8$$

1,8 = 9/5

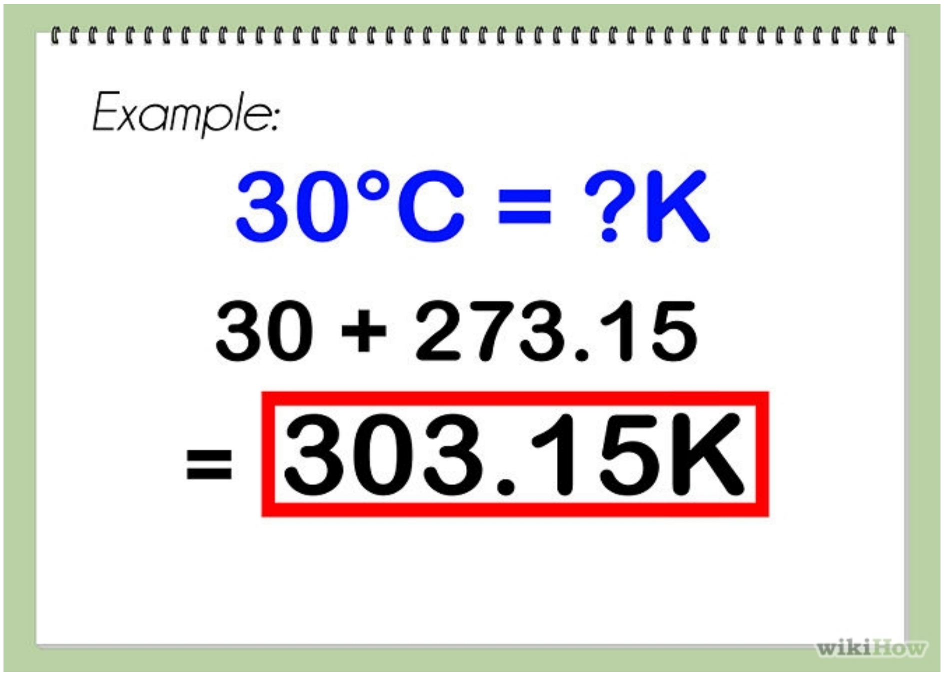
The Celsius scale is in general use wherever metric units have become accepted, and it is used in scientific work everywhere.

Example		
Problem	**Water freezes at 32ᄎ F. On the Celsius scale, what temperature is this?**	
	$C = \frac{5}{9}(F - 32)$	A Fahrenheit temperature is given. To convert it to the Celsius scale, use the formula at the left.
	$C = \frac{5}{9}(32 - 32)$	Substitute 32 for *F* and subtract.
	$C = \frac{5}{9}(0)$	Any number multiplied by 0 is 0.
Answer	The freezing point of water is 0 ᄎC.	

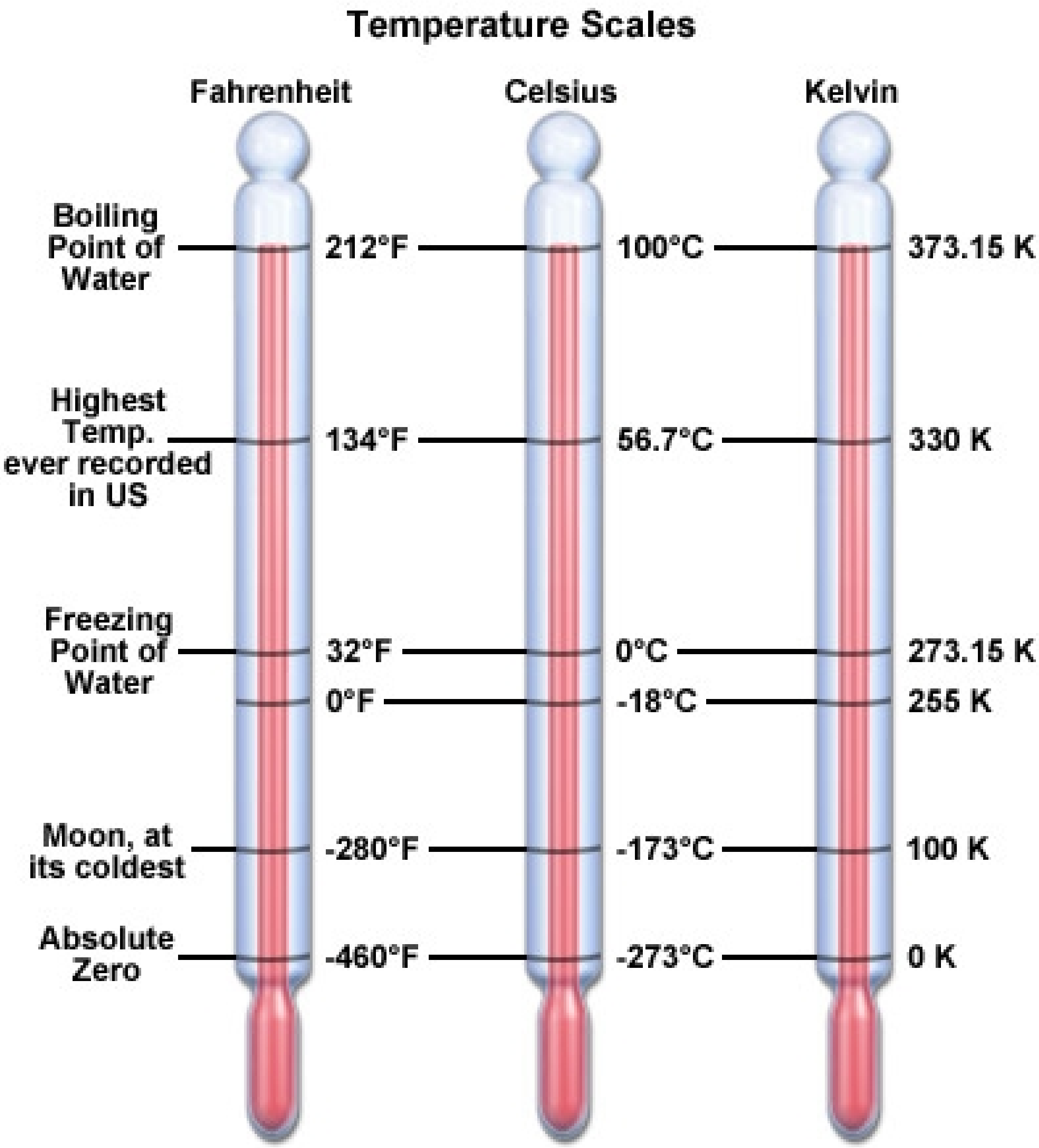
- *Kelvin temperature scale* is the base unit of thermodynamic temperature measurement in the International System (SI) of measurement. It is defined as the triple point (equilibrium among the solid, liquid, and gaseous phases) of pure water. Such a scale has as its zero point absolute zero, the theoretical temperature at which the molecules of a substance have the lowest energy. Kelvin scale has been adopted as the international standard for scientific temperature measurement. It is related to the Celsius scale. The difference between the freezing and boiling points of water is 100 degrees in each, so that the Kelvin has the same magnitude as the degree Celsius. The way to convert from degrees Celsius to Kelvin is:

Celsius to Kelvin:

$$K = {}^{\circ}C + 273.$$



The three different temperature scales have been placed side-by-side in the chart below for comparison.


Temperature Scales
Fahrenheit
Celsius
Kelvin
Boiling Point of Water
212°F
100°C
373.15 K
Highest Temp. ever recorded in US
134°F
56.7°C
330 K
Freezing Point of Water
32°F
0°C
273.15 K
0°F
-18°C
255 K
Moon, at its coldest
-280°F
-173°C
100 K
Absolute Zero
-460°F
-273°C
0 K

Thermal expansion

Is the tendency of matter to change in volume in response to a change in temperature, through heat transfer.

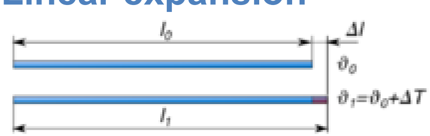
Temperature is a monotonic function of the average molecular kinetic energy of a substance. When a substance is heated, the kinetic energy of its molecules increases. Thus, the molecules begin moving more and usually maintain a greater average separation. Materials which contract with increasing temperature are unusual; this effect is limited in size, and only occurs within limited temperature ranges. The degree of expansion divided by the change in temperature is called the material's **coefficient of thermal expansion** and generally varies with temperature.

Coefficient of thermal expansion

The **coefficient of thermal expansion** describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure. Several types of coefficients have been developed: volumetric, area, and linear. Which is used depending on the particular application and which dimensions are considered important. For solids, one might only be concerned with the change along a length, or over some area.

The volumetric thermal expansion coefficient is the most basic thermal expansion coefficient. In general, substances expand or contract when their temperature changes, with expansion or contraction occurring in all directions. Substances that expand at the same rate in every direction are called isotropic. For isotropic materials, the area and linear coefficients may be calculated from the volumetric coefficient.

Linear expansion



Change in length of a rod due to thermal expansion.

To a first approximation, the change in length measurements of an object ("linear dimension" as opposed to, e.g., volumetric dimension) due to thermal expansion is related to temperature change by a "linear expansion coefficient". It is the fractional change in length per degree of temperature change. Assuming negligible effect of pressure, we may write:

$$\alpha_L = \frac{1}{L}\frac{dL}{dT}$$

where L is a particular length measurement and dL/dT is the rate of change of that linear dimension per unit change in temperature.

The change in the linear dimension can be estimated to be:

$$\frac{\Delta L}{L} = \alpha_L \Delta T$$

This equation works well as long as the linear-expansion coefficient does not change much over the change in temperature ΔT. If it does, the equation must be integrated.

Volume expansion

For a solid, we can ignore the effects of pressure on the material, and the volumetric thermal expansion coefficient can be written:[5]

$$\alpha_V = \frac{1}{V}\frac{dV}{dT}$$

where V is the volume of the material, and dV/dT is the rate of change of that volume with temperature.

Thermal conductivity:

In physics, **thermal conductivity** is the property of a material to conduct heat.
It is evaluated primarily in terms of Fourier's Law for heat conduction.
Heat transfer occurs at a higher rate across materials of high thermal conductivity than across materials of low thermal conductivity.
Thermal conductivity of materials is temperature dependent.
The reciprocal of thermal conductivity is called thermal resistivity.

Measurement:

There are a number of ways to measure thermal conductivity.

Each of these is suitable for a limited range of materials, depending on the thermal properties and the medium temperature.

There is a distinction between steady-state and transient techniques.

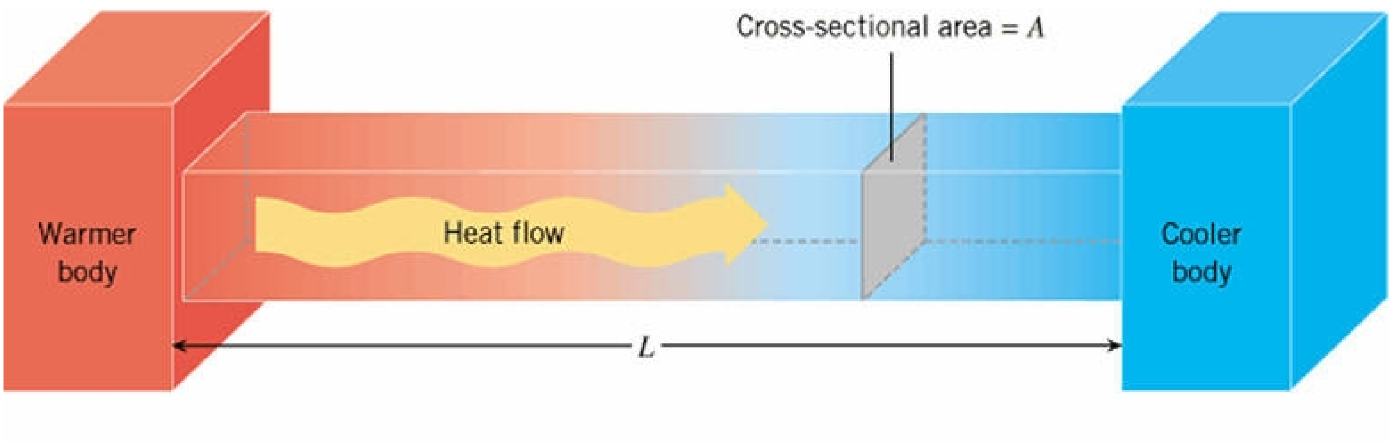
In general, steady-state techniques are useful when the temperature of the material does not change with time. This makes the signal analysis straightforward (steady state implies constant signals).

Definitions:

Conductance:

For general scientific use, *thermal conductance* is the quantity of heat that passes in unit time through a plate of *particular area and thickness* when its opposite faces differ in temperature by one kelvin.

thermal conductance=Q = *kA*/*L*, measured in $W \cdot K^{-1}$



$$P_{cond} = \frac{Q}{t} = kA\frac{T_H - T_C}{L}.$$

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